

METHOD AND APPARATUS FOR DETERMINING A MAGNIFICATION FACTOR OF A RADIOGRAPHIC IMAGE

BACKGROUND OF THE INVENTION

[0001] This application claims the benefit of a priority under 35 USC 119 to French Patent Application No. 01 04 160 filed March 28, 2001, the entire contents of which are incorporated by reference.

[0002] The invention relates to image acquisition methods by an X-ray radiography apparatus designed, in particular, for angiography.

[0003] In vascular imaging, in many cases, it is important to be able to identify the actual size of arteries from images from the X-ray radiography apparatus. This is because stenosis, a narrowing of the artery, is frequently treated by introducing a balloon into the artery and then by dilating the balloon to the size of the healthy artery. The size of the healthy artery is determined by measuring the artery on each side of the lesion due to the stenosis. This measurement is used to select a balloon of suitable size to treat the stenosis. The images from the x-ray radiographs are projections. Consequently, a magnification factor is determined to indicate the actual size of the artery from its size in the image. Several approaches have been proposed in order to calculate the magnification factor. One approach currently used is to locate a catheter (or any other object whose size is known) in the image and to determine its size in the image. The actual size of the object is entered into the apparatus. Thus, the magnification factor for the object is determined. Assuming that the distance to the projection center is similar for the object and for the artery, the same magnification factor is used to determine the size of the artery. This approach has several disadvantages. First, it requires the user to provide information which is not directly connected with the pathology, that is to say, the size of the instrument which is used as a calibration object. Should there be an error, a poor measurement is made. Second, the applied algorithm assumes that the calibration object and the artery to be measured are close to each other. This is almost never the case. Furthermore, in certain situations, when the user wishes to employ a catheter as a

calibration object, the catheter is not necessarily visible on the image selected in order to measure the artery. This may lead to considerable errors of accuracy in determining the size of the artery, which is detrimental to the proper treatment of the stenosis.

BRIEF DESCRIPTION OF THE INVENTION

[0004] The present invention is to provide an embodiment of a method and an apparatus for determining the magnification factor. In an embodiment of the invention, a method of determining a magnification factor in a radiography apparatus of the type comprising means for providing an X-ray source and means for acquiring images, the source and the image acquisition being mounted so as to rotate about at least one axis with respect to an object to a support on which an object to be X-rayed is intended to be positioned, comprising acquiring at least two images corresponding to two different angular positions of the source and of the image acquisition with respect to the support; identifying on these images projections of at least one point of the X-rayed object; and determining the magnification factor of at least one of the images, first as a function of the angular displacement of the source and of the image acquisition between the acquisitions of the images in question and, secondly, as a function of the positions on these images of the identified projections.

[0005] Further, an embodiment of the invention is directed to an X-ray radiography apparatus, comprising means for providing an X-ray source and means for acquiring images, the source and the image acquisition being mounted so as to rotate about at least one axis with respect to a support on which an object to be X-rayed is intended to be positioned, the apparatus comprising means for processing the images acquired by implementing an embodiment of the method.

[0006] Also, in an embodiment of the invention, a method of acquiring vascular radiographic images by means of a radiography apparatus of the type comprising means for providing an X-ray source and means for acquiring images, the source and the image acquisition being mounted so as to rotate about at least one axis with respect to a support on which an object to be X-rayed is intended to be

positioned, a method where a magnification factor is determined by implementing an embodiment of the method.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The invention and embodiments thereof will become apparent from the following description and the appended drawings, in which:

Figure 1 is a schematic view of a radiography device for implementing an embodiment of a method for determining a magnification factor of a radiographic image; and

Figure 2 is an outline diagram showing the taking of two images from two different angles during an embodiment of the method.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Referring to Figure 1, an X-ray radiography apparatus 1 comprises means for taking a radiography image 2 and means for emitting X-rays 3 in the form of an X-ray source. The means for taking a radiographic images 2 is, for example, a digital camera. The X-ray source 3 and the camera 2 are attached to each end of an arm to form, in this example, a semicircle. The arm 7 is connected to a second arm 8 by, for example, sliding. The second arm 8 is itself connected, for example, by sliding and by rotating to a stand 9 of the radiography apparatus 1.

[0009] Arm 8 is capable of carrying out rotational movements 6 about its own axis. Arm 7, capable of sliding with respect to the arm 8, makes a rotational movement 5 with respect to the center of the semicircle forming arm 7.

[0010] In use, an object to be imaged, for example, the body of a patient, is positioned between the X-ray source 3 and the camera 2, so that an artery 4 to be X-rayed is in the imaging field 10 of the device. Artery 4 is then at a distance z from the X-ray source 3. By construction, the camera 2 is at a distance Z from this same X-ray source 3. The image of the artery 4 taken by the camera 2 is a projection whose magnification factor f is equal to the ratio Z/z .

[0011] In order to be able to calculate the magnification factor f , the X-ray radiography apparatus 1 determines the distance z , given that the distance Z is known because of construction of the apparatus. For this purpose, with reference to Figure 2, the radiography apparatus takes a first image I_1 while the source 3 is in position X_1 in order to create an image at a first acquisition angle α_1 with respect to a reference R . The artery 4 is identified on the image I_1 by its projection $4'$. Next, the X-ray radiography apparatus 1 takes a second image I_2 at a second acquisition angle α_2 with respect to the reference R , the X-ray source 3 then being in position X_2 . Again, the artery 4 is identified on the image I_2 , by its projection $4''$. Given the successive positions of the X-ray source 3 and X_1 and X_2 , it is possible, by using triangulation calculation methods, to determine, on the basis of projections $4'$ and $4''$ of the artery 4, the spatial position of a point P of the artery 4 in the imaging field 10 of the radiography apparatus 1.

[0012] The triangulation comprises the determination of the coordinates of a point P belonging to the artery 4. For this purpose, the projection P' of the point P is identified on the image I_1 . Given the coordinates for the position X_1 of the X-ray source 3, the equation of the straight line D_1 passing through X_1 and P' is determined. Similarly, the projection P'' of the P is identified on the image I_2 . Given the coordinates for the position X_2 of the X-ray source 3, the equation of the straight line D_2 passing through X_2 and P'' is determined. The point P whose coordinates are sought is located in the middle of the segment of the common perpendicular of the straight lines D_1 and D_2 , connecting the straight lines D_1 and D_2 .

[0013] Given the spatial position of the point P of the artery 4, the radiography apparatus 1 can calculate the distance z separating the artery 4 from the X-ray source 3, for any one of the images taken. Hence, it thereby determines the magnification factor of this image in question and thereby deduces the actual size of the artery in question.

[0014] In order to displace the X-ray source from the position X_1 to the position X_2 , the arm 7 rotates about the artery 4, either in the direction of rotation 6, or in the direction of rotation 5. The direction of rotation is chosen by the user according

to the conditions of use of the radiography apparatus 1. During this rotation, the X-ray radiography apparatus takes a series of successive images in a burst at an acquisition rate varying, for example, from 15 images per second to 30 images per second. The series of images can be stored in a plurality of memories (not shown) of the radiography apparatus 1.

[0015] In order to carry out triangulation to determine the spatial position of the artery 4, the separation $\Delta\alpha$ between the angles α_1 and α_2 is, for example, between 15° and 45° . Preferably, the separation $\Delta\alpha$ is equal to 20° . In order to rotate through an angle $\Delta\alpha$, the X-ray radiography apparatus 1 displaces the source 3 along one of the aforementioned directions of rotation 5, 6 at a rate of between, for example, 30° per second and 40° per second. For example, the radiography apparatus 1 is capable of taking a series of about 15 images for a separation $\Delta\alpha$ of 20° , at a speed of 40° per second, and for an image acquisition rate in a burst of 30 images per second. Over this series of images each one comprising a different projection of the artery 4, the radiography apparatus 1 will track the artery 4 by means of an image processing method which is implemented by a processor (not shown) of the radiography apparatus 1 which has access to the plurality of memories having stored the series of images. This image processing method enabling tracking of this kind can be carried out, for example, in two ways: First, either the apparatus determines a region around the artery 4 to be tracked and tracks this region throughout all the images constituting the series of images by optimizing a similarity criterion such as the correlation, or second the apparatus segments the artery over the first image and monitors this segmentation over the images constituting the series. Such tracking methods are described in the following publications: Zhaohua Ding & Morton H. Friedman "Quantification of 3-D coronary arterial motion using clinical biplane cineangiograms", the International Journal of Cardiac Imaging, No. 16, pages 331 to 346, 2000; and Deriche Rachid and Faugeras Olivier, "Tracking line segment", Image and vision computing, Volume 8, No. 4, pages 261 to 271, November 1990.

[0016] The X-ray radiography apparatus 1 implementing the method of acquiring and monitoring an artery is designed to be used mainly during surgical procedures within an operating theatre. The user positions the radiography apparatus 1 around the object to image for example, a patient, so that the artery 4, which is desired to be studied is in the image field 10 of the radiography apparatus 1. Since the camera 2 and the X-ray source 3 are aligned at an angle α_1 with respect to the reference R, the user takes a first image which will indicate to the radiography apparatus the artery 4 which is to be studied. Next the radiography apparatus 1 rotates the camera 2 and the X-ray source 3, which are in alignment, to an angle α_2 with respect to the reference R. During this rotation through an angle $\Delta\alpha$, the apparatus takes a series of images in a burst, as has been described above. Over this series of images, the apparatus tracks the designated artery 4, determines the spatial position of the artery 4 in the imaging field 10 of the radiography apparatus 1 by means of triangulation. The magnification factor f is determined in order to be able to provide the user with the actual size of the artery 4 which is to be studied, from the size determined from the projection of the artery 4 on at least one of the acquired images. The apparatus will then be able to determine the exact shape of the artery in the form of variations of the cross section over a given segment, from the series of images.

[0017] Thus, it is no longer necessary for the user to enter the size of a known object. The position of the artery is determined in the imaging field of the radiography apparatus triangulation given the displacement angle and the position of the projections. Knowledge of this position makes it possible to determine the distance from the artery to the X-ray source. Knowing the distance from the image to the X-ray source of the radiography apparatus as a result of its construction, the magnification factor of this image can be accurately determined.

[0018] The embodiment of the apparatus and method has at least one of the following characteristics: at least two images on which an identification is carried out for the purpose of determining a magnification factor are acquired for angular positions separated by an angle greater than 15° ; at least two images on which an identification is carried out for the purpose of determining a magnification factor are acquired for angular positions separated by an angle greater than 20° ; during an image

acquisition, a plurality of images is acquired between a first and a second angular position; identification of the projections implements automatic tracking of at least one point of the object from one image to another, on the plurality of images acquired; the automatic tracking implements monitoring by means of a similarity criterion of at least one region of the object; the similarity criterion is a correlation criterion; the automatic tracking implements monitoring of at least one segment that is identified on the images.

[0019] Various modifications in structure and/or steps and/or function may be made by one skilled in the art without departing from the scope and extent of the invention as recited in the claims.